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CHEMICAL & ENGINEERING NEWS

C&EN

OCTOBER 12, 1992

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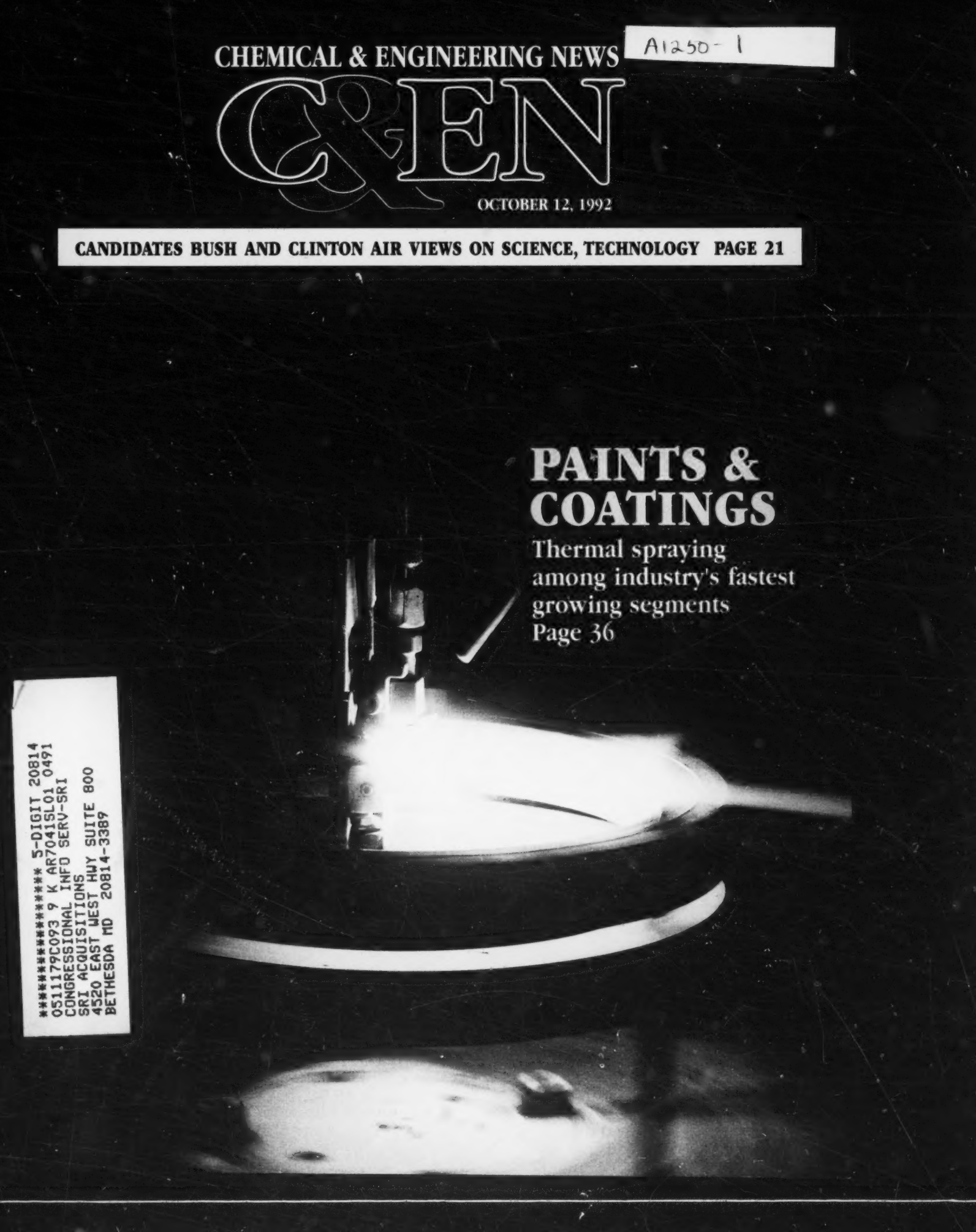

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CHEMICAL & ENGINEERING NEWS

C&EN

OCTOBER 12, 1992

NEWS OF THE WEEK

■ President Bush has waived volatility restrictions for reformulated gasoline, encouraging the use of ethanol in gasoline. Page 8

■ Congress' final days were marked by a frenzy of activity, with the Senate approving an energy bill but still at work at press time on a major tax bill. Page 9

■ Downsizing of research labs, other drastic shifts in science are forecast by former science adviser Edward David Jr. Page 9

■ Dutch scientists plan to probe the feasibility of raising the ground level along the coast by converting subsurface limestone to gypsum with sulfuric acid. Page 10

■ Ernest Volwiler, president of the American Chemical Society in 1950 and retired chairman of the board of Abbott Laboratories, is dead at 99. Page 10

COVER: Metco plasma gun sprays aluminum-bronze soft bearing coating inside the bore of piston guide

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BUSINESS

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DNA and other aspects of the biotechnology revolution were addressed at well-attended public symposium held at San Francisco's Exploratorium Museum. Page 34

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Chemical & Engineering News
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LETTERS

Scientific smokescreen

I take strong exception to the letter of Edwin A. Matzner (C&EN, Sept. 7, page 4), in which he more or less encourages the media to let us "experts" in the sciences handle the decision-making process involved in applying or developing technologies. I would like to point out that scientific "objectivity" and "logic" are often merely smokescreens behind which lurk personal, professional, and political ambitions.

May I use as examples the recent spate of government and society reports that predict a dire shortage of scientists and engineers in the near future and that encourage massive increases in federal spending on research and education. More knowledgeable persons than I have debunked the underlying statistics and economic assumptions of these reports, but I would like to add my own personal observation: I seem to be a member of a growing host of young and talented scientists who are unable to find professional employment in our fields of specialization. I, and many of my peers in similar situations, view such self-serving proclamations with increasing cynicism and disbelief.

I, for one, welcome the scrutiny of the media, despite its numerous faults and excesses. The increasing number of media reports about scientific fraud, misconduct, and pork-barrel funding indicate that the primary problem facing science today is not personnel shortages or decreasing levels of funding, but is in fact hubris.

Michael J. Sherrod
Farmington, Me.

Science, technology, and society

Your report on the symposium at the national meeting on "scientific illiteracy" (C&EN, Sept. 14, page 31) highlights a new and pervasive problem within the science community. In research, the problem is reflected in the particularly American habit of ignoring the literature, difficult as it is to keep up with all of it. It is not, however, at all difficult to capture much of the enormous value in knowledge available in three telephone calls and a single computer search. Indeed, as scientists, we should be very aware of the public money we waste when we reinvent wheels or rediscover the well known.

Around 1970, groups of scientists at Stanford; Cornell; Penn State; and the State University of New York, Stony Brook, among others, caught up in one of Rupert Sheldrake's morphogenetic fields, became aware of the failure of the college system to make an impact on the general student's knowledge of both science, and even more pressingly, technology, and to put them into the context of society, started on those campuses what has become the "Science, Technology, and Society" (STS) movement. This has led to the institutionalization on several dozen campuses of our most prominent universities and colleges of departments or interdisciplinary units of STS. The movement entered the K–12 system a decade later and is today by far the most widespread reform of science education in schools. It is a genuine grass-roots megatrend. Professionals from all disciplines, university faculty, K–12 teachers, industrial researchers, and public interest activists have been meeting together (a sine qua non) regularly for over two decades to address the problems some of your speakers and audience seem to have rediscovered—scientific illiteracy. Actually, a decade ago, after many symposia, some under the American Association for the Advancement of Science aegis on "scientific illiteracy," the preferred term for what all citizens should know about science and technology, became "technological literacy."

There exists today a professional society, the National Association for Science, Technology & Society (NASTS); a journal, *Bulletin of Science, Technology & Society*; and an annual meeting held every year in Washington, D.C. The 8th Annual Technological Literacy Conference will be held Jan. 15–17, 1993.

Occasional symposia at single professional society meetings are excellent for stimulating some more scientists of that

Letters to the Editor

C&EN encourages readers to contribute to this letters section. However, please keep letters reasonably short—400 words or fewer. Because we receive a heavy volume of letters, persons writing letters are limited, as a general rule, to one letter within any given six-month period.

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Sagging U.K. Chemical Industry Expected To Turn Up This Year

■ ***Strong pharmaceutical sales and reorganization of the government's trade department will give lift to industry***

Patricia L. Layman, C&EN London

Chemical industry analysts tend to be a gloomy and cynical lot. But these days, when they say of the British chemical industry, "It's on its knees," there is an underlying sense that that's not a far-fetched exaggeration of the state of health of the industry, which last year accounted for sales of $51 billion.

In a way, a robust chemical industry would be surprising: The U.K. is one of two countries in Europe (the other is Sweden) whose economies are actually contracting rather than growing, declining at a rate of 0.8% so far this year. According to Dun & Bradstreet, Britain has recorded more than 46,000 business failures in the first nine months of 1992, almost as many as in the entire year of 1991. Unemployment is running at nearly 10%, with 2.8 million people out of work. Basic industries that are heavy customers of the chemical industry—for example, housing and construction, automobiles, consumer durables—are in a woeful state. The sectors of the chemical industry supplying those industries are, in turn, experiencing slumps.

On the other hand, the largest single sector of the British chemical industry, pharmaceuticals—which make up roughly one third of the industry's total sales—is basking in strong sales, growing markets, and expanding research and development commitments.

After having toured the country's chemical companies, Ray R. Knowland, president of the U.K.'s Chemical Industries Association (CIA), and retired chairman of BP Chemicals, said the basic chemicals side of the industry is trying to work out "which year the recession is going to lift." Pharmaceutical producers, however, can respond: "Recession? What recession?"

Henderson: lower interest rates needed

In fact, the chemical industry this year is expected to show an overall growth in production of as much as 1% over 1991, because of the strong growth of the pharmaceuticals sector. Without that support, the industry's production would be down 1.5 to 2%, according to current estimates.

Many of the problems facing the U.K.'s economy have followed from high interest rates (more than 10% during the past several years) and a strong pound sterling rate. High interest rates have been regarded as a major squelcher of economic activity—house sales and construction, auto financing, and the like. And the high cost of the pound, particularly against a much weaker U.S. dollar, has cut into exports while encouraging imports, affecting domestic industrial output.

However, the economic storms of September, which took Britain and Italy out of the European rate mechanism within the European Community and devalued the pound, the Italian lira, and Spain's peseta, were welcomed as a relief by the business community in particular (C&EN, Sept. 28, page 7).

Although chemical industry managers support the goal of eventual monetary union, with stable currency conditions, they agree that, for now, it is more important for Britain to tend to strictly domestic concerns. Lower interest rates to spur economic growth came almost immediately, with a base rate of 9%. The weaker dollar was expected to almost immediately translate into improved export opportunities for the chemical industry.

"We desperately need a stimulus to growth from lower interest rates, which would help to ease both the debt burden being carried by corporations and individuals," says Sir Denys Henderson, chairman of British chemicals giant ICI. "Action has also clearly been needed to assist U.K. exports, which have been suffering from the unrealistically high value of sterling. I am mightily relieved that the decision has been taken to float sterling. It will certainly make life less difficult for those of us who are substantial exporters."

Exports are important for the chemical industry—and for the U.K. Last year, the industry posted $24.7 billion worth of exports, compared with imports of $19.5 billion. That made chemicals the country's top export earner in the manufacturing sector in 1991, according to CIA, which points out that 48% of chemical sales were export sales. Of those, some 55% went to other EC countries.

Its trade record helps reinforce the chemical industry being part of an increasingly global industry—and it must compete on a global basis. Governmental attitude becomes increasingly impor-

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Scottish chemical industry has distinct differences

It's not quite the Gulf Coast of Britain, but the Forth River in Scotland has managed over the years to become the center of the chemical industry in that country.

At Mossmorran, just over the Firth of Forth, north of Edinburgh, lies Exxon's massive ethylene cracker, which, in turn, is adjacent to Shell's natural gas liquids plant. Further up the river, west toward Glasgow, is Grangemouth, a town with chemical ties since the 1920s. There, more than 5000 workers are directly employed by the industry and another 10,000 in the broader economy. In fact, according to the Grangemouth Development Group, the chemical industry accounts for almost 48% of the Forth Valley gross domestic product.

And just as the Scots have proudly and determinedly kept their national identity and burr, the chemical industry in Scotland has some distinct differences from that of England and Wales.

"The English chemical industry is different than the Scottish," if in no other respect than its larger captive customer base, says Ted Ferguson, general manager for BP Chemicals at Grangemouth. "Look around Scotland—who's using our materials, our feedstocks? This spot has an advantage over Mossmorran in our downstream customers, all sorts of customers making their livings from the direct feedstocks from chemical plants in Grangemouth. There are no other capabilities like that in Scotland, but several in England—it has a larger pool to draw on."

As a result, Scotland has always looked for export markets, points out Del Blake, general manager of Exxon's Mossmorran plant. "We are not serving a Scottish market. We're not even serving the U.K. As a generality, we are serving Western Europe."

Notes Alex Salmond, leader of the Scottish National Party: "The Scottish economy is one of the export powerhouses of Europe—we are one of the strongest exporting countries in Europe. Scotland is competitive in international terms, not badly placed."

However, it faces stiff competition as a potential company site. As Blake points out, "ninety percent of the chemical industry in Scotland is made up of the big players—such as BP, ICI, Exxon, Rohm & Haas, and Glaxo. All of those companies have a choice as to where to put investments. Demand will generally be in mainland Europe—Benelux, France, Germany, for instance. All other things being equal, firms wouldn't necessarily put investment in Scotland.

"If you don't have a marketplace in your favor, you need to be competitive with elsewhere in Europe," he adds. "Why would people come to Scotland? From a strategic point of view, there are feedstock availability, distribution of production capability, and land availability."

Mike Andrews, managing director of Rohm & Haas (Scotland) and current chairman of the Scottish regional committee of the U.K.'s Chemical Industries Association, agrees. "A lot of companies have been here a long time, but some companies have come here for some of those very reasons," he says. "For example, there is the North Sea natural gas, for feedstocks. And there is availability of land for future expansion: Mossmorran, for example,

tant then and questions are raised. Is there an understanding of business needs, an understanding of the consequences of legislation affecting the industry? For the British chemical industry, the signs are increasingly positive.

This summer, for example, the government's Department for Trade & Industry (DTI) was reorganized by Michael Heseltine, secretary of state for trade, "to relate more closely to sectors of industry." Among the points to be emphasized at the time was the adoption of a sectoral approach to the industries for which the department is responsible.

"The new structure will allow for the establishment of some new divisions, and the recasting of some previously existing divisions, to establish a division dealing with industrial competitiveness," he says, "together with a range of sectoral divisions dealing with industries including chemicals and biotechnology, and steel."

Under the reorganization, one government minister is delegated to be responsible for the different sectors. There is a minister assigned, for example, to handle chemicals and biotechnology, as well as steel, metals and minerals, vehicles, aerospace, electronics and electrical engineering, and mechanical engineering.

CIA, for one, has welcomed the plan, seeing it as a means for the department to

was a greenfield site when Exxon built its cracker there in the 1980s."

Moreover, transportation links with the "rest of the world" are being upgraded, particularly rail. As Ferguson points out, a new railhead is being built southwest of Glasgow, that will provide improved, through service to the south of Britain and the Continent, when the Channel Tunnel is built. "That will give us direct links down there—it will be very important to us."

One of the major differences for industry in Scotland, compared with England and Wales, is the system of property taxes. The difference can be significant, indeed, says Exxon's Blake: "The rates we pay in Scotland are about £10 million (roughly $18 million). If this cracker were at Fawley (Exxon's cracker complex on the south coast of England), it would be about £2 million."

Adds Ferguson, the British government is promising to introduce uniform business rates throughout the nation, so, in time, this difference will be resolved. But for the time being, he notes, "It doesn't add to the attractiveness of Scotland."

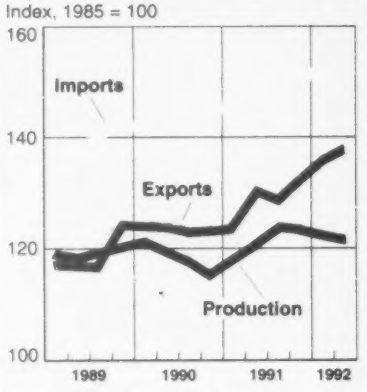
One of the advantages of Scotland, however, is that it is concentrated in a small region. Not only do chemical industry staffers meet regularly to provide guidance on implementing corporate Responsible Care programs, for example, but they also meet frequently with government officials, from local councils and groups to the British government's Scottish Office. Discussion points might include such things as tax rates and water and energy costs.

be more responsive to the needs of industry. The association's director general, John Cox, says,"I am pleased to see that DTI will have a minister who will take a personal interest in the needs of our sector, which is one of the most valuable contributors to Britain's balance of payments. I am particularly pleased to see that biotechnology is recognized as being important."

As Cox sees it, the reorganization signals a willingness by government to "achieve a dialogue in understanding the scientific decisions made, with full knowledge of the facts. A lot of that applies at the national level, but clearly, more and more at the European decision level," he points out. "That depends on the Council of Ministers, so we must make sure the ministers know on these few important issues, the full facts, and the consequences of their decisions—where the hidden advantages and disadvantages are, depending on how European laws are applied."

In part, the DTI reorganization comes in response to the abolishment of the National Economic Development Office (NEDO), a tripartite organization consisting of government, industry, and labor, designed to encourage different industrial sectors both within the U.K. and as international competitors. For political reasons the British government has decided to abolish the organization at the end of this year.

U.K. chemical output down, but exports and imports up



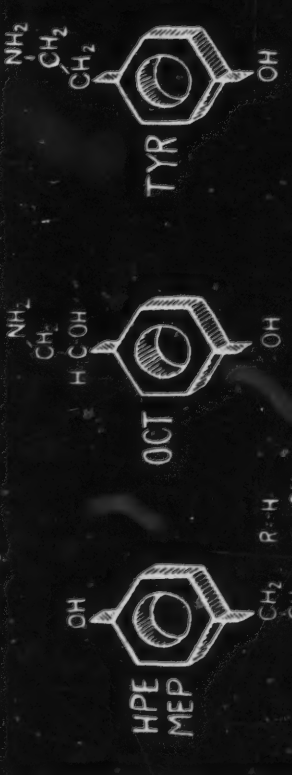
Source: U.K. Central Statistics Office

Pharmaceuticals account for third of chemical sales

$ Billions	1991 sales	% change 1990–91
Pharmaceuticals	$16.8	5.0%
Industrial specialties	9.2	na
Organics	6.1	5.0
Soaps, toiletries	5.1	–5.8
Plastics	3.1	–3.5
Paints, inks	3.1	–5.0
Dyes, pigments	2.6	0
Inorganics	2.0	–10.5
Household chemicals	2.0	na
Fertilizers	1.0	–9.0
TOTAL	$51.0	0.0%

na = not available Source: Chemical Industries Association

Developmental Intermediates



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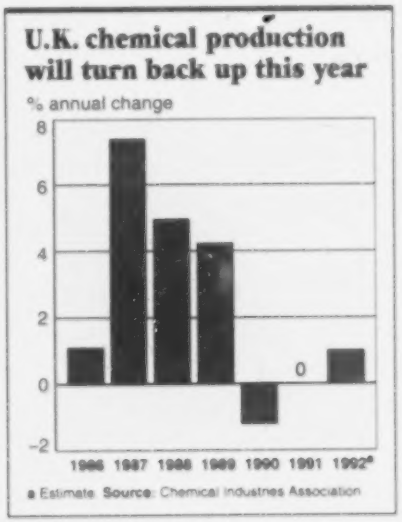


One result has been to make the major organizations representing various industries that much more important for lobbying to government. That, in turn, is arousing an interest in the more specialized sectors of the industry, for more formalized representation before government.

Last month, for example, CIA president Knowland proposed a Specialized Organic Chemicals Sector Association, separate from, but integrated with and involved with CIA, with ready access to CIA's common services such as parliamentary and media affairs. In a way, this would replace the specialized organics group within NEDO, which had been one of its more active groups.

Among the lobbying grounds for CIA are the problems of energy costs and availability, particularly vexing for the U.K. chemical industry. Large electricity users, such as ICI, with its chlor-alkali operations, have already begun vigorous public campaigns to convey the message that U.K. power costs are disproportionately high.

On the other hand, one area in which the industry must fight its own lonely battle is in recruitment into the industry. It's not a problem now, companies report, but they are worried about the pipeline of entering people—it is not filling up. In part, this reflects the low opinion held by the general British population of the chemical industry. But it also reflects what has been happening in the industry as well.

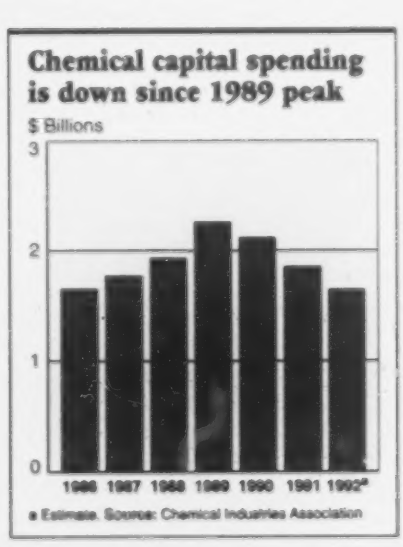
Employment in the chemical industry has fallen from 383,000 in 1981 to just under 300,000 this year. The annual graduate recruitment survey, published by CIA, shows that this year the industry expects to recruit 21% fewer graduates than last year. The reason given in this year's survey: depressed trading conditions worldwide.

Graduate recruitment by the chemical industry has fallen substantially from the high levels of 1989 and 1990, the survey indicates. Only in biological science does the decline appear to have halted. Chemists are the largest category of recruits, accounting for nearly 30% of the total recruited in 1992. The next largest category is chemical engineers, at 18%.

However, the results will strike a familiar chord with observers in the U.S. With graduate recruitment going down, students are reacting to this message of the marketplace, and opting for other careers. Careers in finance are particularly appealing in the U.K., whether in "the City," London's equivalent to Wall Street, or in the abundantly populated profession of accounting.

Industry is working with the education profession to train teachers, on the theory that that can help inspire scientific career choices later on in a student's life. Says Cox, "You won't have people in science at the university and college level, unless they have had exciting science at the younger levels.

"Our determination on educational issues is here to stay. For now, we are tending to attract and retain the talent we want—but we want it to be on a positive basis, not because there's a recession in the City. We want people to make this industry their first choice." □



SCI medalist airs views on industry issues

This week, H. Eugene McBrayer, former president of Exxon Chemical, will receive the Chemical Industry Medal. The American Section of the Society of the Chemical Industry (SCI) awards the medal for "conspicuous service to applied chemistry."

McBrayer succeeded Edwin C. Holmer as president of Exxon Chemical and like Holmer he is also now a recipient of the SCI Medal. McBrayer retired in 1990 after 20 years with Exxon Chemical and 37 years with Exxon Corp. During his career at Exxon, he served on the board of the Chemical Manufacturers Association (CMA), retiring from the organization after serving as its 1990–91 chairman.

In a recent interview with C&EN, McBrayer discussed some of the issues he sees as most important, including chemical industry credibility and the condition of science education in the U.S., two issues he says are intertwined.

McBrayer says that if the chemical industry is unable to attract capable people, the industry could well lose its innovative edge. The current climate of opinion is set against the chemical industry, he says, and, in turn, affects the educational choices young people make in selecting their careers.

The problem is not at the university level. In fact, there the technical level of achievement is "outstanding." However, in the lower grades science literacy is suffering. One reason, perhaps, is that the chemical industry has lost credibility. Increasingly, polls "find us more the source of problems than of solutions," McBrayer says.

The step the industry has taken in adopting its Responsible Care program, he says, will go a long way both toward changing public attitudes about the chemical industry and gaining wider acceptance for chemistry as an acceptable career path. McBrayer was involved in much of the early planning for the Responsible Care program, the industry's comprehensive commitment to health, safety, and the environment. It was during his tenure as CMA chairman that the organization instituted its $8.5 million advertising program to open a dialogue with the public about

Paints and Coatings Sales Top $11 Billion

Thermal spray impinges on traditional polymer coatings; prices of titanium dioxide have moderated for now

Marc S. Reisch,
C&EN Northeast
News Bureau

Although actual industry shipments of paints and coatings may have declined in 1991, it may not have been such a bad year. Paint sales, after all, did exceed $11 billion. Specifically, paint sales for 1991 totaled $11.4 billion, down 3% from $11.8 billion in 1990. As the industry reformulates coatings to satisfy environmental concerns, fewer gallons of paint may be produced, but more area may be covered. It is a classic case of doing more with less. In the case of paint, higher solids coatings cover more area per gallon while emitting fewer volatile organic compounds (VOCs). The discussion that starts on this page cites the salient statistics.

However, these statistics do not include data for thermal-spray coatings which are the subject of a discussion beginning on page 45. This small but growing technology has been around since the 1920s, but it is now gaining momentum. Improvements in equipment able to heat, melt, and discharge metals, ceramics, carbides, and even plastic materials allow thermal-spray operators to coat metal, wood, plastic, glass, or even paper with high-performance coatings. Although these thermal-spray coatings are not traditional polymer-type paints and coatings, they do provide unusual coatings that are unobtainable in any other way. Thermal-spray coatings can provide improved resistance to abrasion, corrosion, and weathering in a variety of high-technology applications from aircraft engines to bridge maintenance.

Meanwhile, in the more prosaic world of traditional polymer coatings, titanium dioxide shortages were a big concern just a few years ago. Today, with the addition of new plants and added-capacity facilities both in North America and around the world, the pigment is in plentiful supply. Beginning on page 64, titanium dioxide producers discuss the current market. Although prices may have moderated for the moment, at least one producer, SCM Chemicals, believes prices will have to increase in the future to pay for the new plants now in operation.

Inorganic color pigment producers have an entirely different concern. Although titanium dioxide has a clean bill of health, lead chromates and other heavy-metal pigments may be toxic. Industry suppliers argue that formulated pigments with reduced solubility pose little environmental hazard. In a discussion beginning on page 71, they point out that these pigments, used only in paints for industrial equipment, bridge maintenance, or marking traffic lanes, are cost effective and pose little danger to people. However, regulations pending at the Environmental Protection Agency under the Toxic Substances Control Act (TSCA) may ultimately drive the formulation of coatings with more organic pigments. Not only are environmental groups promoting a shift away from inorganic pigments, but some organic-pigment producers and paint-additive manufacturers are ready to step in with replacements.

Shipments declined 5% last year

If industry statistics are taken at face value, the paint industry was deeply affected by the recession in 1991. The Department of Commerce reports that shipments declined almost 5% that year compared with 1990, to a little more than 1 billion gal.

But the statistics do not tell the full story. Under government pressure to lower levels of VOCs in their products, manufacturers continue to substitute coatings containing a higher percentage of solids. (VOCs are components in the formation of atmospheric smog.) Where practical, users have shifted away from traditional solvent-borne coatings to alternatives such as oven-cured powder coatings or radiation-cured low-VOC liquids.

In addition, the high cost of disposing of overspray captured in industrial settings has prodded users and manufacturers to more efficiently transfer paint or powder from spray gun or applicator to the area to be painted. As a result, coating efficiencies have increased to the point where fewer total gallons cover more area.

Thermal-sprayed zinc particles cool so rapidly the apple is not destroyed

Hobart Labs photos

Thus, industry shipments may not be an absolute indicator of the health of the paint and coatings industry. Indeed, shipment declines may indicate the success the industry has had in doing more with less. According to Bill Broxterman, president of consulting firm ChemQuest, Cincinnati, statistical declines in gallons used do not account for the increase in solids per gallon, or the increasing use of 100% solids powder coatings. "If you were to measure actual coatings coverage on a dry weight basis, it is increasing," he explains.

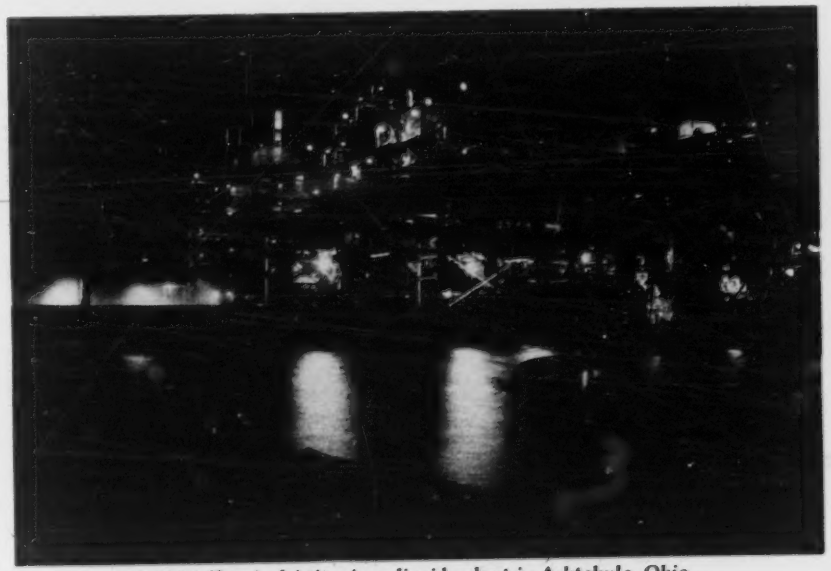
Transfer efficiency has also improved, notes Broxterman, thereby reducing actual volume used and giving the appearance of slower growth. About 20 years ago most industrially applied coatings were sprayed on but only about 20% of the spray actually coated the intended object. Increasing industry use of roller techniques to apply coating to metal coils (used for instance in manufacturing refrigerators, washers, and driers), helped to achieve a transfer efficiency of more than 95%, says Broxterman. Electrostatically applied powder coatings accomplish transfer efficiencies that exceed 90% because the overspray can be captured for reuse, he says.

Looking at the paint and coatings market in actual dollar terms, the value of industry shipments approached $11.4 billion in 1991. Although that may be an actual dollar decline of 3% from 1990, Commerce Department figures may be revised, as they were for 1990, and the trend may be up again by as much as the government data show they have declined this year.

For instance the Department of Commerce revised its 1990 shipment data upward nearly 10% from what it showed in its reports last year at this time. Similarly, it revised the value of those shipments upward by more than 1%. But what is important is that long term the actual number of gallons shipped between 1987, a year when the U.S. economy was strong, and 1991, when it was weak, has hardly increased—remaining at a little more than 1 billion gal. Similarly, the value of those shipments—up about 3% annually—has hardly increased considering the rate of inflation.

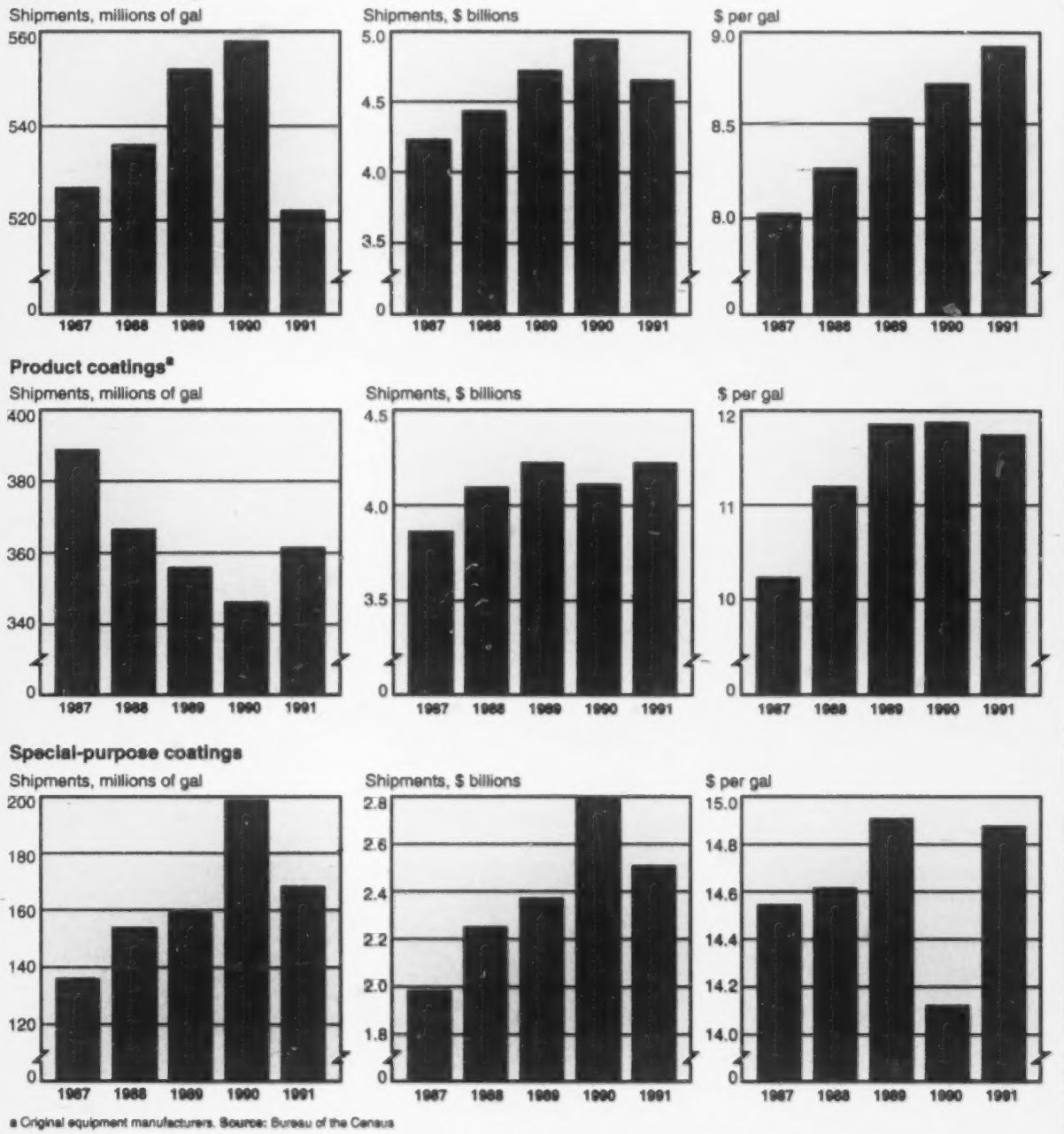
However, despite their shifts, government data show clearly that the paints and coatings industry overall is a mature, slow-growth industry. Broxterman notes that paint industry demand grows slower than gross national product. It is an industry in which opportunities present themselves to paint suppliers either as technology shifts to favor one supplier over another or as competitors attempt to increase market share. At the same time it is a besieged industry that must fund the development of alternative technologies as it comes under environmental and regulatory pressures.

New environmental regulations loom on the horizon, notes consultant Kline & Co.'s business manager of adhesives and coatings, Jeffrey Back. He



SCM Chemicals' titanium dioxide plant in Ashtabula, Ohio

Product coatings shipments rose, but others declined

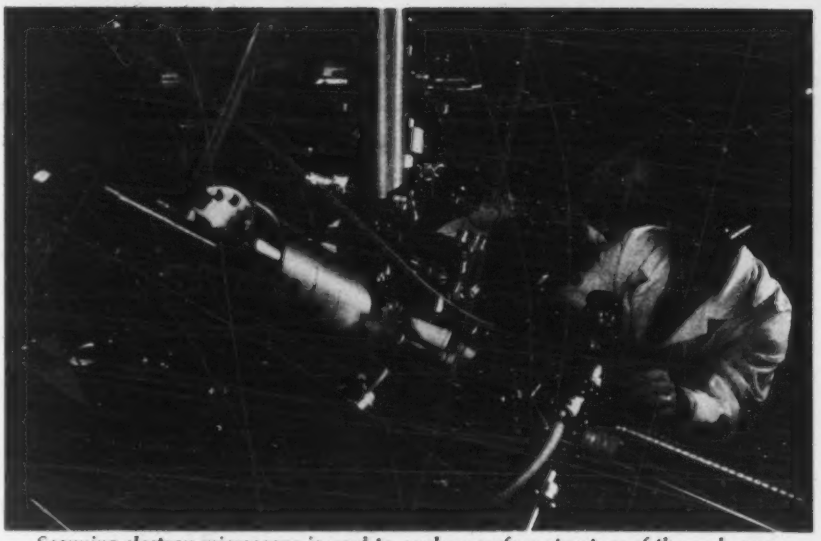


a Original equipment manufacturers. Source: Bureau of the Census

warns that EPA will be promulgating regulations in the next 18 to 24 months that will affect hazardous chemical emissions and some paint chemicals, including isophorone, napthenol, toluene, ethylbenzene, methylchloroform, xylenes, and all the glycol ethers.

The industry paid for its continued reformulation efforts and the development of alternative technologies in part through increases in the average price charged per gallon of paint shipped. In 1991, the average price per gallon rose almost 2% to $10.84, compared with $10.68 in 1990 and with $10.58 in 1989.

The industry continued its reformulation efforts even with those modest price increases, in part because of lower raw materials costs during the current recession. Paint material prices declined marginally in 1991 compared with 1990, according to the latest data from the Department of Labor. For the first eight months of 1992, preliminary



Scanning electron microscope is used to analyze surface structure of thermal-spray coatings at Air Products & Chemicals headquarters

data show those costs have increased marginally.

Manufacturers have wrung additional savings through reductions in employment and concomitant increases in productivity. A look at the Department of Labor's paint and coating industry employment data shows that overall employment has been slipping since 1989. Although employment dropped about 2% in both 1989 and 1990, the decline accelerated in 1991 to over 5%, bringing total industry employment to 57,900. That is the lowest level in 10 years. The industry produced 193 million gal more of coatings in 1991 than in 1983, when nearly the same number of production employees, 29,500, worked in the industry.

Mergers and acquisitions also tend to reduce industry costs as larger producers are able to gain through manufacturing and distribution efficiencies. However, the pace of mergers and acquisitions has slowed over the past year. One major acquisition stands out—Rohm & Haas acquired Unocal's emulsion polymer business, including six U.S. plants and a technical center in Charlotte, N.C., for approximately $175 million. Rohm & Haas also strengthened its international position in acrylic emulsions by increasing its ownership of Japan Acrylic from 48% to 67%. The company did not disclose the cost of its increased holdings, purchased from partner Toagosei Chemical.

Rohm & Haas sees advantages to increasing its position in the emulsion polymers business, and a recent report from the Freedonia Group, Cleveland, may explain why. The report, "Paint Polymers & Chemicals," predicts that the paint chemical mix in the next few years will increasingly favor higher priced chemicals such as resins, pigments, and additives while demand for solvents, which tend to be lower in price, will continue to decline.

Total paint chemical demand, which Freedonia sets at just under 11 billion lb in 1991, will rise to nearly 12 billion lb by 1995. The total value of paint chemicals likely will rise from the present $5.7 billion to $7.2 billion in 1995. The study projects that the weight of chemicals per gallon of paint will drop from 10.4 lb in 1991 to 9.5 lb in 1995, largely because of the shift to water-borne coatings.

According to the study, the paint chemical category that will have the highest annual growth is organic pigments, whose use could increase nearly 10% annually to 55 million lb in 1995. The study notes that cadmium, chromium, and lead-based inorganic pigments are all under environmental scrutiny, though it projects their use will still grow about 4% annually to 320 million lb in 1995. A number of pigment suppliers have stopped supplying some inorganics, but organic counterparts are more expensive by a factor of three to five times "and generally perform less well," notes the Freedonia study.

These paint chemicals are used in architectural coatings, which accounted for half of industry shipments in 1991; followed by product coatings, which accounted for a little more than a third of shipments; and special-purpose coatings, which made up the remaining 16% of total paint shipments. Shipments of architectural coatings in 1991, which include paints applied both to interior and exterior surfaces, declined more than 6% from the previous year to 522 million gal. The value of those shipments also declined about 4% to $4.65 billion. The unit price per gallon rose only a little more than 2% to $8.91. The recession continues to have a negative impact on these coatings markets. Whereas housing starts improved toward the latter part of the year, they still lagged previous years. This category still accounted for nearly half of industry shipments, and was little changed from the year earlier.

Shipments of product coatings, which consists of the original equipment market, last year rose a little more than 4% from the previous year to 361 million gal. The value of those shipments also

Architectural coatings dominated business in 1991

Special-purpose coatings 16%
Product coatings[a] 34%
Total 1991 shipments = 1.05 billion gal
Special-purpose coatings 22%
Product coatings[a] 37%
Total 1991 shipments = $11.4 billion

a Original equipment manufacturers. Source: Bureau of the Census

rose about 3% to $4.24 billion. Unit price per gallon however decreased 1% to $11.75. A good market for U.S. exports helped increase paint shipments to product manufacturers who subsequently exported finished products. As a result, the total value of product coatings rose compared with last year, but slow finished product demand on the domestic front kept product coatings unit prices under pressure.

Special-purpose coatings shipments declined nearly 15% from 1990, according to the government figures, to 168 million gal. The value of those shipments also declined more than 10% to $2.5 billion. However, unit prices increased 5% to $14.88, reflecting increased costs as paint makers reformulated their products to satisfy environmental regulations. A large measure of the reduction may be accounted for in the government sector. The length of the recession and its effects on municipal finances have in many cases forced municipalities to postpone maintenance on bridges and other outdoor structures.

Three main paint categories break down this way

ARCHITECTURAL COATINGS
- Exterior house paints
- Interior house paints
- Undercoaters, primers & sealers
- Stains

PRODUCT COATINGS[a]
- Wood furniture & fixtures
- Automotive
- Metal containers
- Machinery & equipment
- Factory-finished wood
- Metal furniture & fixtures
- Sheet, strip & coil
- Nonautomotive transportation
- Appliances
- Electrical insulation
- Marine
- Film, paper & foil
- Pipe
- Toys & sporting goods
- Miscellaneous consumer & industrial products

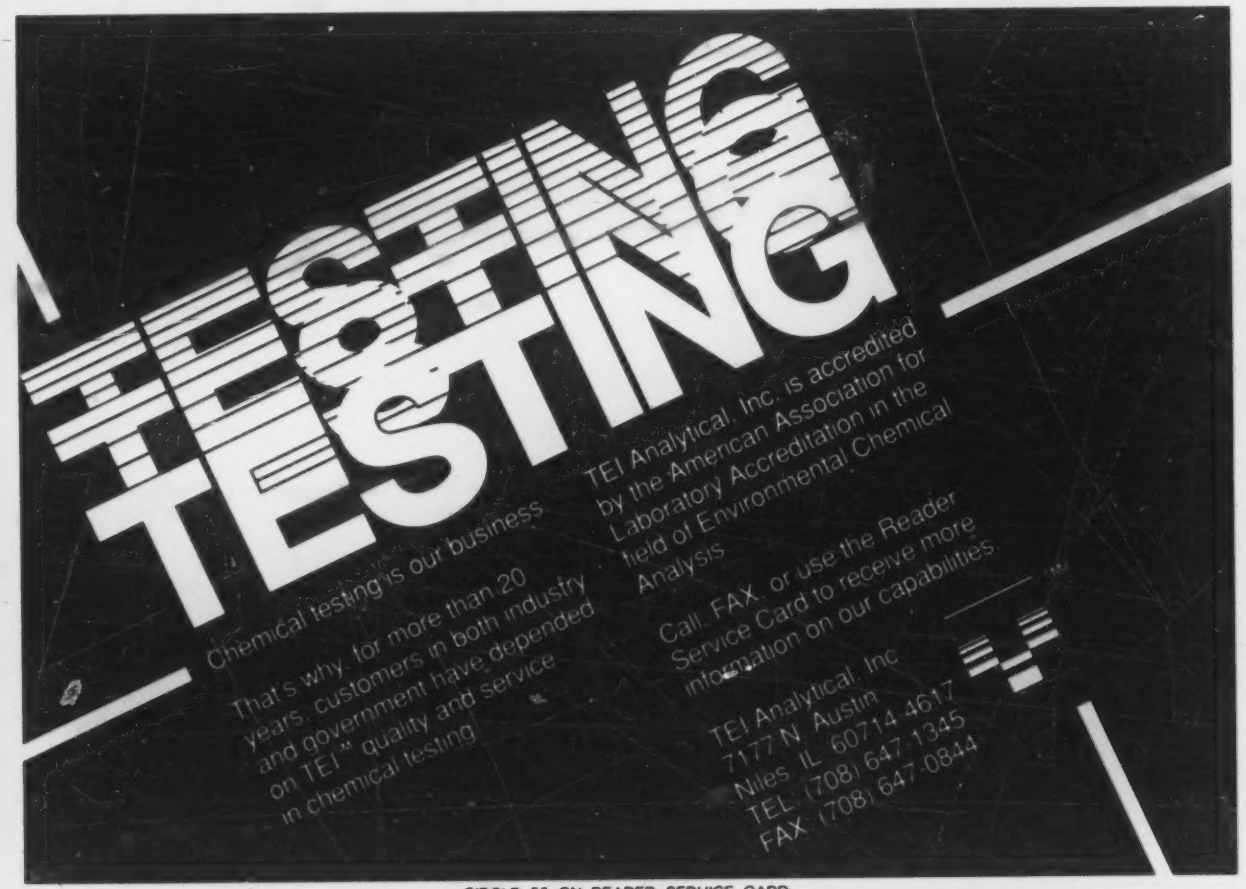
SPECIAL-PURPOSE COATINGS
- Automotive & machinery refinishing
- High-performance maintenance
- Traffic paint
- Roof coatings
- Bridge maintenance
- Aerosols
- Swimming pool coatings
- Arts & crafts
- Metallic coatings
- Multicolored coatings

a Original equipment manufacturers. **Source:** SRI International

Thermal-spray techniques impinge on traditional coatings markets

As the technology to apply thermal-spray coatings has improved, these metal, ceramic, and carbide materials promise to outperform traditional polymer paints and coatings. In rugged environments, they may outperform traditional bridge and industrial facility coatings. They may also provide surer footing on oil rig platforms or tanker trucks because they do not degrade rapidly under severe service conditions.

Thermal-spray applications of metals, ceramics, and carbides can also provide durable and rugged coatings where very few other coatings will sur-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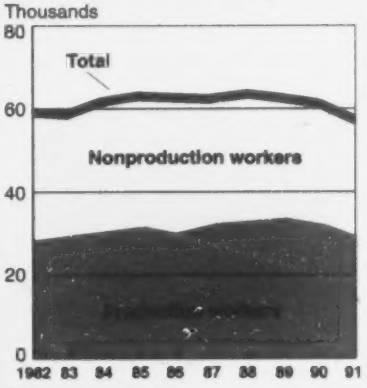
Employment continues to slip in paint industry



Source: Department of Labor

vive, such as in the high-temperature environment of an aircraft turbine engine, or on the walls of an industrial boiler. Thermal-spray carbide coatings can extend the life of industrial drill bits used for oil well drilling. New technology also makes it possible to thermally spray plastic materials onto metal substrates for outstanding salt and corrosion resistance on structural steel bridge components or in industrial maintenance settings.

Thermal spraying is itself a generic term for a number of coating processes that heat, melt, and propel metallic, ceramic, carbide, or plastic particles onto a substrate. The particles flatten upon impact and bond to the substrate. Thermal-spray coatings can be applied to a variety of materials including metals, oxides, ceramics, glass, plastics, wood, and even paper. Not all sprayable materials can be applied to all substrates. Thermal-spray processes include detonation, wire flame, powder flame, wire arc, high-velocity oxygen fuel (HVOF), plasma, and radio plasma.

Plasma-gun operators need eye and ear protection because of the bright light and heat these guns generate. Plasma-gun operators must also protect their skin from the intense ultraviolet light the guns produce. Cost of thermal-spray equipment ranges from $5000 for a simple flame spray gun to about $1 million for a computer-controlled plasma gun and spray-booth setup.

Thermal-sprayed coatings may be decorative when, for instance, they are applied over a metal sculpture. They can provide wear resistance, or reclaim worn or improperly machined parts in-place, such as huge industrial paper-mill rollers. Aerospace engine manufacturers use the coatings to create thin thermal barriers on turbine blades, thus raising the effective operating temperature of the engine and improving fuel efficiency.

Many of these high-technology applications exceed the capability of traditional coatings and might be labeled niche markets. Estimates on the size of the world market for thermally applied coatings, including equipment, materials, and job shop applications, range from well under $1 billion to over $2 billion. Estimates of the size of the U.S. market alone range from $500 million for materials, equipment, and job shop applications to just over $700 million.

Growth estimates for the thermal-spray coating industry run between 5 and 8% a year, though most insiders suggest that 1992 has been a slow year with little or no growth. Since aerospace applications make up close to 40% of thermal-spray coatings volume, the current military and commercial aerospace industry slowdown has certainly put a crimp on the growth

Paint materials demand to grow 1.1% annually through 1995

Millions of lb	1991	1995	% annual change 1991–95
Synthetic resins	2,420	2,830	4.0%
Alkyds	6,610	7,400	2.9
Acrylics	661	740	4.8
Vinyls	462	545	4.2
Epoxies	185	210	3.2
Other resins	462	550	4.5
Pigments	1,199	1,435	4.6
Titanium dioxide	889	1,060	4.5
Other inorganics	272	320	4.1
Organics	38	55	9.7
Solvents	5,014	4,736	−1.4
Additives	177	213	4.7
Minor paint chemicals	1,983	2,325	4.1
TOTAL	10,793	11,539	1.7%

Source: Freedonia Group

Alpha Olefins Answers

Roger C. Williamson, Ph.D.

Q: *I have an interest in olefins with a methylene group near the center of the molecule. Can these be prepared from your linear olefins?*

A: Our research determined optimum reaction conditions for this chemistry utilizing an aluminum alkyl (preferably tri-isobutyl aluminum) as a catalyst in an inert atmosphere. A temperature of 185-200 °C and an initial catalyst concentration of 0.5% gives reasonably fast reaction times of four to five hours. The conversion is limited to 55-65% due to the product competing with the starting alpha olefin for catalyst.

For simplicity, and since all aluminum alkyl bonds in tri-alkyl aluminums react the same, we abbreviate $Al\text{-}R_3$ to al-R in the following chemical reactions:

$$al\text{-}CH_2\text{-}\underset{\displaystyle CH_3}{CH}\text{-}CH_3 \xrightarrow{135\ ^\circ C} al\text{-}H + CH_2{=}\underset{\displaystyle CH_3}{C}\text{-}CH_3$$

$$al\text{-}H + R\text{-}CH{=}CH_2 \longrightarrow al\text{-}CH_2\text{-}CH_2\text{-}R$$

$$al\text{-}CH_2\text{-}CH_2\text{-}R + R\text{-}CH{=}CH_2 \xrightarrow{185\ ^\circ C} R\text{-}\underset{\displaystyle (CH_2)_2}{\underset{\displaystyle R}{CH}}\text{-}CH_2\text{-}al$$

$$R\text{-}\underset{\displaystyle (CH_2)_2}{\underset{\displaystyle R}{CH}}\text{-}CH_2\text{-}al \longrightarrow R\text{-}\underset{\displaystyle CH_2}{\underset{\displaystyle \|}{C}}\text{-}(CH_2)_2\text{-}R + al\text{-}H$$

A competing side reaction produces a linear internal olefin so the final reaction product consists of $R\text{-}\underset{\displaystyle CH_2}{\underset{\displaystyle \|}{C}}\text{-}(CH_2)_2\text{-}R$(90%)+$R\text{-}CH{=}CH\text{-}(CH_2)_2\text{-}R$(10%). The reaction mixture is then cooled and washed with 25% NaOH. After drying, the mixture is distilled to recover starting olefin and the product as a bottoms.

Interestingly, the 1-tetradecene dimer (2-dodecyl-1 hexadecene) is a liquid at room temperature and undergoes most of the same chemical reactions as the linear alpha olefins.

If you have any questions about alpha olefins, please contact our Houston office.

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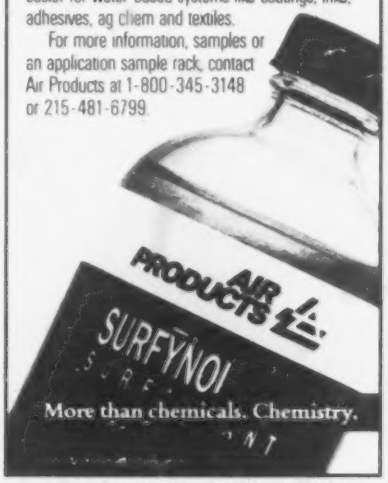

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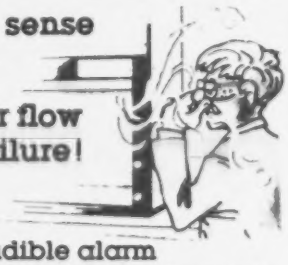

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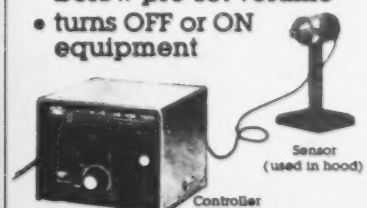

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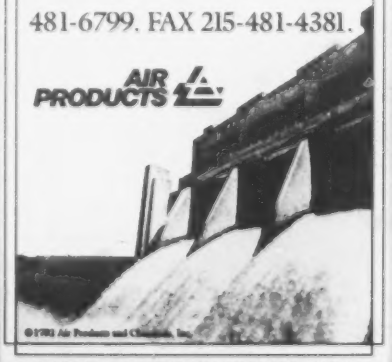

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CIRCLE 2 ON READER SERVICE CARD

PRODUCT REPORT

of thermal-spray coatings. However, when the economy recovers, most industry observers see a market that will double in size in 10 years, particularly if Detroit automakers perfect and qualify thermal coatings for use in engine manufacture. In that event, industry observers believe the market could be $300 million, or in other words, as large as the aerospace market is now.

However, these thermal-spray market figures are dwarfed by the $11 billion U.S. market for traditional architectural, original equipment, and special-purpose polymer coatings. The industry is so small, the Department of Commerce does not even categorize it or collect separate data on it, say those who follow the thermal-spray industry. About all that is clear is that the U.S. does not include thermal-spray coatings in its definition of the paint and coatings industry, and so the data collected by the government do not include thermal-spray coatings industry information.

A major producer of thermal-spray equipment is Perkin-Elmer's Metco Division in Westbury, N.Y. It is among the largest equipment producers with about $123 million in annual sales, including sales of powder and wire. The Surface Technology Division of Swiss engineering company Sulzer has global revenues of $70 million annually for both thermal-spray equipment and powders. In the U.S., the company operates a thermal-powder supply business, Sulzer Plasma Technik, based in Troy, Mich., and an equipment supply unit, Electro Plasma, in Irvine, Calif., specializing in sophisticated plasma-spray units for aerospace engine manufacturers.

Another major player is Hobart Tafa, Concord, N.H. This company boasts that its sales will be $20 million this year from thermal-gun and spray-booth equipment, powder, and wire. Miller Thermal, formed by welding-equipment manufacturer Miller Electric in 1985, supplies powder from the former Alloys International plant of Baytown, Tex., and equipment from Appleton, Wis., with expertise derived from two companies it purchased: Metallizing Co. of America and Plasmadyne. Miller Thermal also has annual sales of about $20 million.

Praxair's Surface Technology, Indianapolis, is in a class all its own. It does not sell equipment, but manufactures

equipment for its own use at 21 facilities worldwide. Praxair contracts with aerospace engine manufacturers or industrial maintenance units within the chemical process or oil exploration industry to coat parts to customer specifications with tungsten carbide, chromium carbide, and ceramics using its proprietary detonation gun. It has a separate ceramic-powder manufacturing operation from which it supplies powders to users of other types of thermal-spray equipment. Praxair does not break out sales for its thermal-spray-related businesses, but sources indicate annual sales may be about $200 million.

Other businesses involved in the thermal-spray market are independent wire and powder suppliers, such as Eutectic, a Flushing, N.Y., supplier of powders and elastomeric materials for thermal spray. Industry sources say that about 600 shops service customers, and that additional in-house maintenance users in the pulp and paper, glass mold, electric and gas utility, chemical, and petrochemical industries make use of thermal equipment for repairs.

Frank N. Longo of F. N. Longo Consultants, East Northport, N.Y., is a consultant on the thermal-spray market and writes a report, published by the Gorham Group in South Windham, Me., on the industry. Longo estimates the size of the North American market at between $600 million and $700 million per year. The figure includes equipment sales, powder, wire, contract coating services, and in-house maintenance users. The largest market now is for jet-engine manufacture, which Longo estimates is 40% of the market. Because of the successes jet-engine manufacturers have had in using thermal-spray coatings to provide thermal protection inside jet engines, the coatings are now being developed for stationary gas and steam turbines that may generate electric power.

Because of the overall slowdown in air travel (as well as the declining commercial and military purchases of airplanes) industry growth, normally running at about 7% a year, has slowed considerably, Longo notes. New markets now are developing for metal thermal coatings in industrial boilers to reduce or eliminate corrosion, he explains, but existing coatings systems have not come far enough along to ensure 100% coverage of boiler surfaces.

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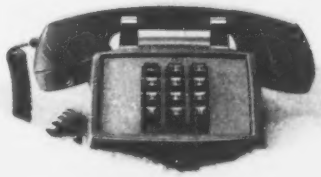

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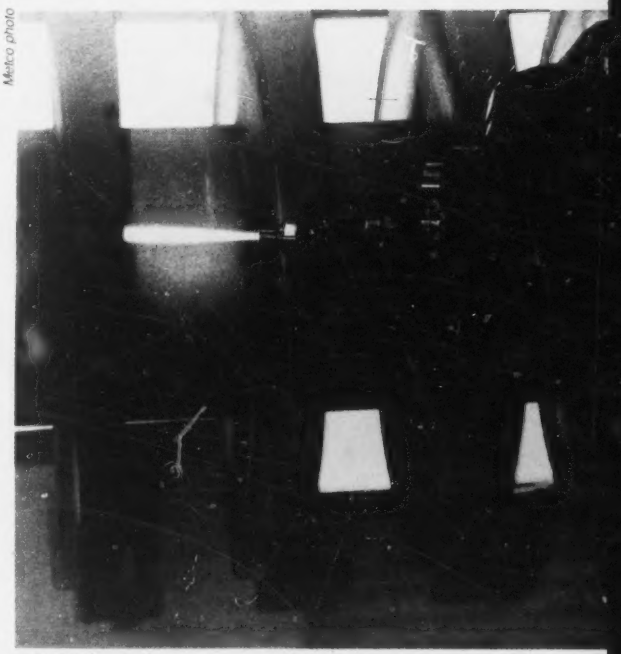
He believes that use of recently developed HVOF-applied coatings can eventually succeed in this market.

The most important developing market, he says, is in automotive gasoline and diesel engines to coat bearing surfaces and to reduce wear on engine cylinders. Detroit automakers already use metal arc-spray techniques to fill in autobody metal seams, but that is a relatively small market that one market manager pins at about $4 million per year. Other potentially large markets are the use of zinc and aluminum for bridge coatings. Europeans have used thermal coatings for at least 30 years to maintain bridge superstructures.

Metco photo



HVOF thermal-spray gun applies coating to metal screw used in waste disposal facility

There is no doubt that for bridge or industrial facility maintenance, thermal-spray costs are much higher than those of traditional polymer applications. For instance, notes Merle Thorpe, president of Hobart Tafa, coating a bridge with traditional polymer applied coatings may cost $1.25 per sq ft including labor and equipment, but using a wire-flame spray coating of zinc may cost $5.00 to $6.00 per sq ft.

Robert H. Unger, vice president of Hobart Tafa, says conventional galvanizing provides only a thin coating that will protect steel from rust for two to three years in a corrosive environment. Application of paint over the galvanized steel may extend total life to eight years. Six mils (1 mil = $\frac{1}{1000}$ inch, a measure of coating thickness) of zinc spray applied to the steel superstructure of a bridge might extend the bridge maintenance cycle to 25 years or longer. Thicker coatings would provide a longer cycle. He estimates that Europeans thermally spray more than 40 million lb of zinc annually for corrosion protection. But U.S. thermal-spray applicators use less than 2 million lb of zinc annually (and most of that is for a noncorrosion application—zinc is applied to polypropylene paper for the manufacture of electrical capacitors).

Unger says zinc may also be applied to concrete structures to provide cathodic protection of reinforced concrete bridge decks. About 8 mils of zinc applied with wire-arc spray guns and then wired to a source of current can prevent corrosion of the rebar steel in reinforced concrete, thereby preventing concrete spalling. He estimates the useful life of such a system at about 10 years and the cost at between $7.00 and $11 per sq ft of concrete surface, including preparation, application, and surface sealing.

Another developing thermal-coatings market is boiler-tube protection, particularly where high-sulfur coal may be used to fire the boiler. The relatively recent introduction of HVOF spray guns allows applicators to apply denser coatings onto industrial boilers, thereby preventing the penetration of corrosive liquids that can lift a coating and shorten the useful life of boiler tubes. Chromium-nickel coatings perform well in industrial boilers, notes Thorpe, and are applied to thicknesses of between 15 and 60 mils. Though the application may be prosaic, the cost can be high. Costs of thermal boiler coatings now range between $70 and $100 per sq ft, he says. Hobart Tafa has a joint-venture company with International Nickel to supply thermal-spray jobbers with a 45% chromium, 55% nickel wire to coat boiler tubes.

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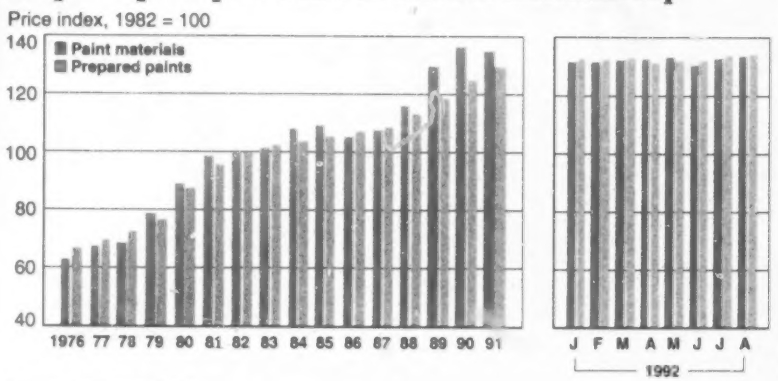
Prepared paint prices rise as those of materials slip



Source: Department of Labor

Costs can vary widely depending not only on the metal, ceramic, or oxide applied, but also on the process, notes Thorpe. Wire arc spray requires an electrical source and a compressed-air source. Wire flame and HVOF can use a mixture of oxygen with either propane, natural gas, hydrogen, or acetylene. Plasma guns require an inert gas such as argon or nitrogen with an admixture of either hydrogen or helium to increase heat content and velocity, and also require an electrical source to generate the plasma. Thorpe says that an HVOF gun his company recently introduced operates on lower cost kerosine as compared with more expensive fuels such as propane or acetylene.

Although zinc, aluminum, and other commodity metals may cost $1.00 to $2.00 per lb in a form suitable for thermal spray, other thermal-spray materials are more expensive. Tungsten carbide, for instance, may cost $20 per lb. Specialty alloys and composite materials may cost as much as $60 to $70 per lb, says consultant Longo, and some patented plastic specialty materials may be as much as $80 per lb. These material costs are certainly in excess of costs for traditional polymer-type coatings.

Because of the high costs of thermal-spray coatings, Kline & Co.'s Back believes that the success of thermal-spray coatings will be limited to niche applications. To expand thermal-spray coatings beyond the niche markets, proponents will have to persuade industrial and municipal customers that the higher costs provide greater benefits. For very costly applications, advocates will have to convince customers that no other alternative exists.

In the aerospace industry, thermal-spray coatings are often the only materials that allow a manufacturer to build a high-performance engine. General Electric research and development center staff scientist Paul A. Siemers says GE uses plasma-applied ceramic coatings as abradable thermal barriers for aircraft engine blade tip seals—a technology he says Metco pioneered. Electro Plasma, the Sulzer equipment manufacturer, helped develop plasma-spray coatings of metallic materials in low-pressure chambers to produce dense, corrosion-resistant coatings. The technology avoids having to oxidize the cobalt-chromium-aluminum-yttrium coatings that may be used on turbine blades.

Siemers says GE has looked closely at low-pressure thermal-spray systems because the company is exploring use of thermal-sprayed titanium, which is "very reactive in air." One possible use of thermal-spray titanium would allow the company to spray a titanium alloy on silicon carbide continuous filaments to make a metal matrix composite. The composite has double the strength and elastic modulus of titanium alone and may be developed for use in jet engines, he says. It is a high-cost technology; titanium-based powders can cost more than $150 per lb.

GE is looking into development of radio-frequency-generating plasma guns because it is interested in spraying titanium coatings, Siemers says. Conventional plasma guns have electrodes that may erode and contaminate the high-purity titanium. The radio-frequency plasma gun the company is developing requires only a 3-inch water-cooled quartz tube to generate the

Varieties of thermal-spray equipment

WIRE FLAME OR POWDER SPRAY: A spark ignites an oxygen and fuel mixture, through which a metal or ceramic rod passes, or into which metal, ceramic, or carbide powders are introduced. A stream of air disintegrates molten material and propels it onto the workpiece. Gun designs differ depending on whether wire or powder is used, but in either case, only materials with melting points below 4500 °F can be sprayed in this process. Wire may be sprayed at rates of 5 to 10 lb per hour, whereas powder rates are 1 to 20 lb per hour.

DETONATION GUN: The gun allows the introduction of oxygen and acetylene into a chamber containing suspended particles. A spark detonates the mixture eight times per second at temperatures that may reach 7000 °F, propelling particles at supersonic velocity toward a workpiece. Praxair, which owns the gun design, custom applies coatings to customer specifications and does not license the technology to others. The gun fires round, wafer-shaped coatings of tungsten carbide, chromium carbide, ceramics, and chrome alloys.

WIRE-ARC SPRAY: Two wire electrodes feed into a gun to form an electric arc. Air, or an inert gas such as nitrogen, fed into the gun passes over the melting wires and propels droplets onto the target. Heat source temperatures can range between 4000 and 15,000 °F. Deposition rate varies from 2 to 150 lb per hour for zinc.

HIGH-VELOCITY OXYGEN FUEL (HVOF): This gun allows the mixture of oxygen and fuel to achieve temperatures of about 5000 °F. Metal, ceramic, or carbide particles exit at speeds approaching or exceeding those of the detonation gun, allowing for the deposition of dense coatings at application rates of up to 30 lb per hour.

PLASMA SPRAY: An inert gas passes through a direct current arc to superheat the gas into which metal, alloy, ceramic, and carbide powder may be introduced. Plasma temperature may exceed 30,000 °F. Spray rates range from 1 to 25 lb per hour, depending on power input, which can vary from 14 to 80 kW.

RADIO-PLASMA SPRAY: An experimental process that uses radio frequencies to generate a gas plasma. The design eliminates electrodes that may erode in conventional plasma guns. General Electric is experimenting with designs, particularly for use in deposition of titanium.

radio frequencies in an inert gas atmosphere within the gun.

Another leading-edge aerospace application is use of tungsten-carbide-cobalt wear-resistant coatings over lightweight plastic composite materials such as carbon-carbon or carbon-epoxy helicopter blades, says Anthony J. Rotollco, engineering director for Metco. However, with the aerospace industry experiencing hard times, Metco and many other equipment suppliers are emphasizing the potential for growth in markets other than aerospace. Metco has perfected a rotating extension for its HVOF gun that allows the inside of an engine cylinder to be coated without having to physically rotate a cumbersome cylinder block. The cost-effective application of wear-resistant coatings to engine cylinders is something of a Holy Grail for the thermal-spray industry.

Another potential future market is in metal-plating replacements. Andrew B. Mazzone, operations director for Metco, points out that many metal-plating operations are under heavy regulatory pressure to reduce or eliminate disposal of spent plating baths. Plating companies can substantially reduce toxic disposals by use of thermal spray instead of plating. Using Hepa filters in controlled atmosphere spray booths would protect both applicators and the environment from metal overspray while substantially reducing disposal problems.

Rotollco also believes that use of glass bottles will increase in the future as plastics disposal problems increase. As a result, he sees Metco benefiting as glass manufacturers not only increase output, but also use more thermal-spray equipment to repair glass-molding equipment. Also under development at Metco is a program to apply ethylene acrylic copolymer plastic sprays to a variety of substrates in order to provide good weatherability and improve corrosion resistance.

Continued on page 62

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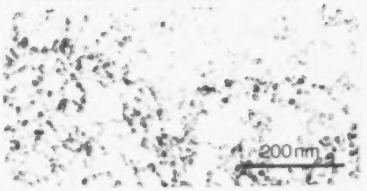

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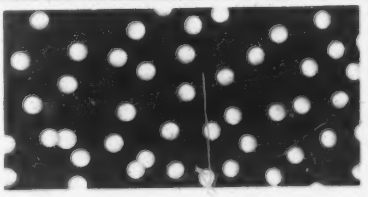

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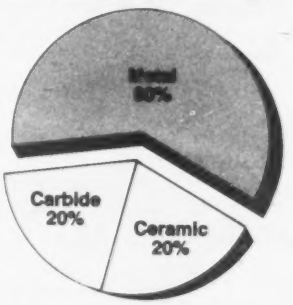
CIRCLE 30 ON READER SERVICE CARD

Continued from page 55

Because the plastics can be applied on site, they may well make durable coatings on bridges, lampposts, or even water towers for Food & Drug Administration-approved plastic color coatings. Tuck C. Nerz, a Metco materials engineer working with the plastic process, says deposit efficiency can be 85 to 90%.

Metco, notes Mazzone, is vertically integrated, manufacturing all its thermal-spray guns in-house. It also manufactures wire and powders to specifications for use in its equipment. Mazzone estimates wholesale costs to spray zinc coatings at $10 per sq ft. Boiler coatings could run at $40 per sq ft depending on the type of alloy used, and aerospace coatings could cost $150 per sq ft, also depending on coatings applied. The bulk of ceramic powders finds its way into the aircraft-engine manufacturing business now, he says, where it provides thermal-barrier coatings.

Metal powders are 60% of thermal-spray coatings



Total 1991 shipments = $130 million

Note: Data are for U.S. and exclude equipment. Does not cover materials for welding processes (plasma non-transferred arc and "puddle torch").
Source: Strategic Analysis Inc.

Jag Govind, a Silver Spring, Md.-based consultant, says that besides the ethylene acrylic copolymers Metco is developing for thermal sprays, nylons and a host of thermosets and elastomerics have been developed by other companies for thermal-spray coatings. However, he estimates that less than 50,000 lb of these materials, costing $6.00 to $10 per lb, are now applied versus about 145 million lb of more conventional electrostatic and fluidized-bed spray powder coatings.

However, Govind, who is working on a powder-coatings report for TPC Business Research Group, Lancaster, Pa., does see thermal-spray uses growing, and if natural-gas fuel for thermal guns can be developed, he sees a potential market for the process worth $200 million in two to three years. The thermal-spray plastics, says Govind, "are not likely to leave pinholes when applied," and as a result can "withstand corrosive environments and are ideal for in-situ applications." But despite their applicability in maintenance coatings, their high price makes them "unlikely to displace traditional polymeric coatings."

Thermal-spray materials supplier Eutectic provides elastomeric and thermoset materials as well as ceramic-metal powders, pure metals such as copper and aluminum, and carbides to service the glass-mold repair, maintenance, and machine-shop markets. The plastic materials must be used in thermal guns designed to accommodate them so that the material does not "burn up" before it reaches its target, says technical services engineer Frank D'Onofrio.

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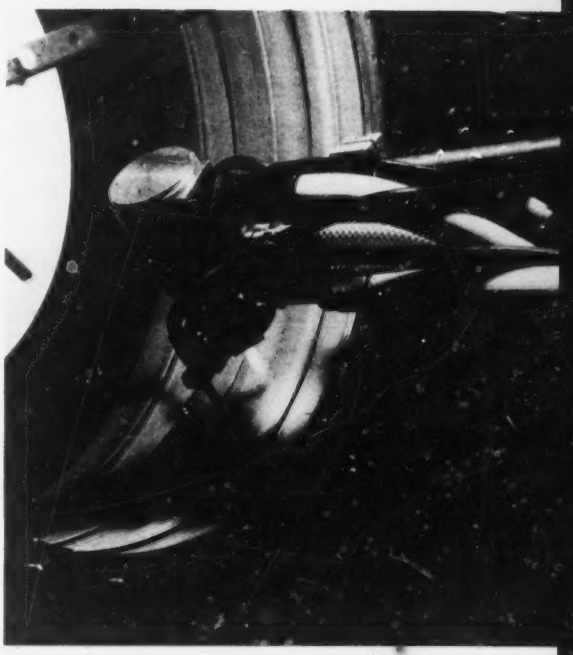
CIRCLE 31 ON READER SERVICE CARD

producer Sulzer Plasma Technik has been adversely affected by the current slowdown in the aerospace industry. "The slowdown has hurt, we all notice it," says the unit's president, John F. Seaman. Because of the drop off, Sulzer too is putting more effort into placing its materials in general industrial applications, he says. As a primary focus, Sulzer is concentrating on the market for coatings in stationary gas turbines used to generate power. Such high-temperature applications for thermal-spray-applied coatings is an area Sulzer knows best, says Seaman. The company is developing high-temperature-resistant gas turbine seals containing a polyester or polyimid combined with nickel, chromium, aluminum, or silicon powders for this market.

Charles P. Howe is communications manager for Miller Thermal, a company that manufactures a full line of thermal-spray equipment. One growing area is the use of plasma-spray equipment in the manufacture of medical implants, he says. In order for human tissue to adhere properly to medical implants such as stainless steel, titanium, or cobalt alloy bone and joint replacements, a coating must cover the implant. Plasma-applied hydroxyapatite forms a porous bioceramic that adheres well to the medical implant and also promotes good tissue adhesion, says Howe.

Howe believes industrial-related thermal-spray business will improve once business picks up in general. One area that will hold promise when the economy turns around is in rebuilding paper finishing rollers in situ with a metal facing that can be "superfinished" to a mirrorlike finish.



Metco plasma gun sprays clearance-control coating onto jet engine combustor liner

Besides Praxair, at least one other industrial gas supplier has more than a passing interest in thermal-spray coatings. Air Products & Chemicals not only supplies gases to thermal sprayers, it has set up a research lab devoted to solving problems affecting thermal sprayers. It has, for instance, developed a specialized propylene fuel it sells under the Apachi trademark to replace hydrogen frequently used in HVOF guns. The Apachi fuel is for applications "less demanding" than aerospace, says barrier-coating group manager Edward Hayduck.

Air Products also has developed two new arc-spray processes. One is for applying corrosion-resistant magnesium-containing coatings, the other is a titanium-nitride coating for wear and corrosion resistance to boilers, rollers, mixing blades, or even within process reactors. Hayduck says Air Products is talking to applicators in an effort to license the technology. The company currently refers to both processes by the Ceramarc trademark.

Titanium dioxide prices finally moderate

Steep price increases between 1987 and 1989 made it appear that the sky was the limit for titanium dioxide—the most widely used white pigment in the paint and coatings industry today. However, annual price increases moderated in 1990 and actually declined during 1991, according to Labor Department figures. A world recession and a number of new facilities coming on-line helped to put a crimp in price increases during the past two years.

Department of Labor figures show that producer prices for titanium dioxide rose at a compound annual rate of more than 10% between 1987 and 1989. However, prices rose a little more than 4% in 1990 from 1989 and actually declined nearly 3% in 1991. Prices have hardly changed during the first six months of this year. Although paint manufacturers may not exactly rejoice over the price situation, they must be heaving a collective sigh of relief. Titanium dioxide is, after all, a major ingredient in paints. Market sources report that U.S. paint producers consume more than 500,000 tons of the pigment annually, valued at more than $900 million.

This is a good time to be a pigment buyer in the coatings industry, says consultant Jim Fisher, president of International Business Management Consultants, Princeton, N.J. Pigment producers have come up with newer, higher performing grades of titanium dioxide, he continues. And because of the more than adequate supply situation, "it's a good time to make sure you have the right supplier and not just a fair-weather friend, particularly if you had a problem in the past getting adequate titanium dioxide supplies." The titanium dioxide business is a cyclical one, he emphasizes. When world economies speed up again, titanium dioxide supply will again be tight.

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Fisher says the early 1980s also saw low pigment prices after a period of expansion in the seventies. But during the eighties government regulations affecting effluent discharges forced a number of plant closures, including those of Tioxide in Billingham, U.K.; NL Industries in Sayerville, N.J.; Gulf & Western in Gloucester City, N.J.; and Dow Chemical in Balboa, Spain. Recent plant additions have reversed the situation. In North America alone, Du Pont, Tioxide, SCM, and Kronos (formerly known as NL Industries), have put into place new plants or expansions.

Titanium dioxide prices are still high—in the 90-cents-per-lb range—compared with what they were five or six years ago. Because of this, paint producers are still motivated to cut their use of titanium dioxide and use more extenders. Says Kline & Co.'s Steve Van Kouteren, many manufacturers have stuck with paint formulas that use more kaolin and calcium carbonate. If producers made the same number of gallons in 1992 as they did in 1988, "you'd see a slight decline in titanium dioxide demand," he says.

According to Jack D. Travis, national sales manager for Du Pont's white pigment and mineral products group, demand for titanium dioxide has increased 3 to 5% so far in 1992 compared with 1991. "This is apt to be a very slow recovery over a long time frame," he says, referring to improved prospects both for paint uses of titanium dioxide and the U.S. economy overall. There is indeed an oversupply now of titanium dioxide, he adds.

That is part of the reason Du Pont put into effect a "voluntary allowance" or discount of 2 cents per lb for titanium dioxide sold in the U.S. market between June 26 and Sept. 30. After September, "we will watch the market and determine if it is appropriate to remove or extend the allowance," says Travis. "Stay tuned," he adds.

Since Du Pont intends to be a titanium dioxide supplier long term, Travis says that service, reliability, and assured supply are some of the strengths Du Pont

SCM Chemicals photo

Titanium dioxide is the most widely used white pigment

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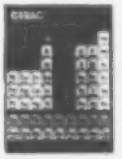

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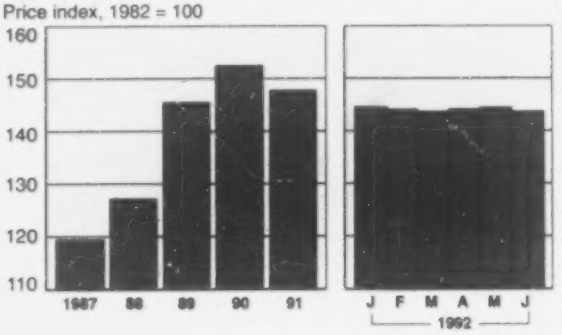
CIRCLE 9 ON READER SERVICE CARD

TiO_2 prices remain below 1990's high



Source: Department of Labor

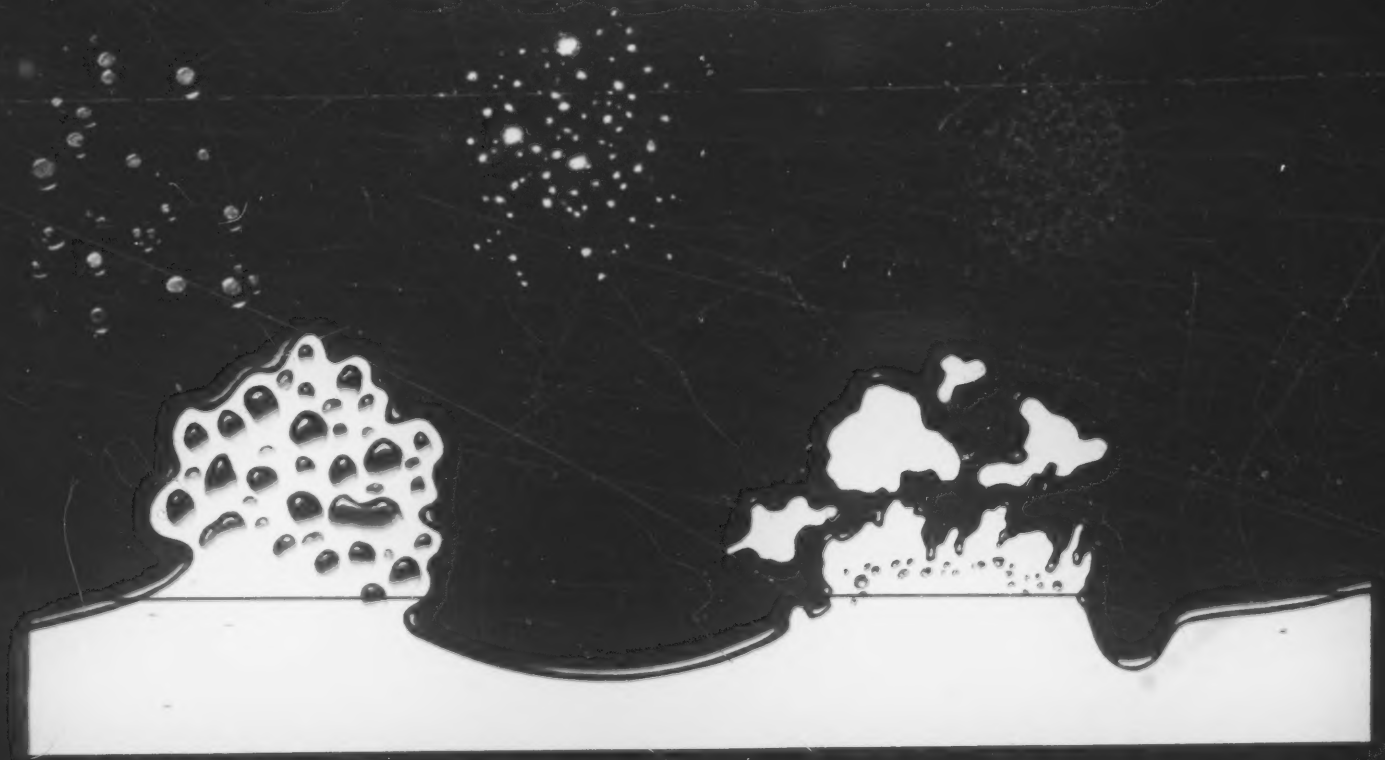
brings to its customers. Within the last year it has also introduced new titanium dioxide pigments—R700 for good dispersion in interior latex paint, and R702, a white pigment for use in durable exterior architectural enamel and industrial finishes.

Donald V. Borst, chairman, president and chief executive officer of SCM Chemicals, says his company has just opened a new 53,000-metric-ton-per-year titanium dioxide plant in Ashtabula, Ohio. Product is "selling strong," and the company is "getting a competitive price" for it. He believes that "we are at the bottom of the titanium dioxide cycle now," and hopes that when Du Pont's voluntary "allowance" ends in September, the price of titanium dioxide will rise a bit. "We need the increase," he says, to pay both for environmental costs and recovery of losses due to inflation. Recently, SCM introduced RCL 535, a new grade of titanium dioxide for coatings with good durability and gloss.

Louis R. Griffis, operations support manager for Kerr-McGee's pigment division, says titanium dioxide is a profitable product "even in these hard times." Kerr-McGee's "level of service has always been pretty high. ... We meet competitors' prices and have increased our market share." The company, which until recently had only U.S. operations, now has a joint venture operating a titanium dioxide plant in Australia, and an equity position in a plant in Saudi Arabia, making the company more of a global player, according to Griffis. Last October the company introduced CR 828, a universal titanium dioxide grade that gives customers more formulating "options" with a single grade, he says.

Engelhard's David E. Gregg, specialty kaolin products marketing manager, points out that though titanium dioxide supply is plentiful now, the company has seen no drop in demand for kaolin used as a titanium dioxide extender. "Earlier titanium dioxide shortages taught paint makers the use of extend-

Problems.



ers." Paint manufacturers who established a paint formula when titanium dioxide supplies were tight have no reason to reformulate now that supplies are more available, he says.

Pigment producers anticipate heavy-metal concerns

Whereas titanium dioxide producers are wrestling with excess capacity and are less occupied with environmental concerns for the moment, the situation is reversed for inorganic pigment producers. Pigment producers are not complaining about excess capacity, but they are worried about the potential impact any regulations might eventually have on inorganic pigments, such as lead chromates.

These pigments are not used in any consumer-applied paints. Instead they are still used in many industrial maintenance coatings for their excellent color retention and durability under severe conditions. Jay Willner, president of WEH Corp., a consulting firm in San Francisco, says the U.S. market for industrial coatings high-performance pigments, including those used for petrochemical and waste treatment facilities, is about $250 million annually.

According to the Dry Color Manufacturers Association (DCMA), about 36 million lb of lead chromate pigment was used in paints in 1989. Other pigments that could be of concern because they too are considered heavy-metals pigments include strontium, mercury, cadmium, and zinc. One market source estimates the value of the heavy-metal industrial pigment market at $30 million annually, excluding titanium dioxide (which, incidentally, has a clean bill of health).

In a 1991 filing with EPA to comment on pending TSCA regulations, DCMA said that lead chromate pigments are used in traffic striping paints for highways and airports, and in safety identification paints on buses, ambulances, and fire trucks. The group also says that soluble lead levels in these pigments are low enough that they pose little hazard

Miller Thermal photo

Zinc-aluminum coating is applied to naval vessel hatch for corrosion protection

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to the environment, and do not at all pose the same threat as did highly soluble lead oxide pigments that were banned a number of years ago.

EPA is moving slowly on any rule making that would affect use of lead chromate pigments in the few areas now allowed. This is an election year, and the President has postponed rule making ostensibly to give businesses some regulatory relief during the current economic slowdown. But the pressure is not off paint makers and formulators.

Environmental groups are concerned about the presence of lead in the environment in any form. "All uses of lead should be phased out as a general matter," states Erik Olson, a senior attorney with the Natural Resources Defense Council (NRDC) in Washington, D.C. Although NRDC supports interim steps toward a complete phase out, Olson believes that ultimately there should be no acceptable exposure level to lead.

Fred Millar, director of the toxics project for Friends of the Earth, another Washington, D.C.-based group, says "there is no excuse for putting more lead in the environment. . . . It's as stupid a thing as I can imagine." Millar contends that substitutes for lead chromate pigments are available, and that formulators should immediately "get on with" not using lead in paints.

Burt Slutsky, market manager for Chicago-based lead chromate producer National Chemical, says few if any nonchromate pigments work as well as the lead chromates. "You pay more and get poorer performance," he claims. But he is aware of the movement toward lead-free products, and explains that lead chromate pigment manufacturers are either replacing their lines, putting off the replacement if they can, or getting out of the lead chromate business. Still, rumors of lead chromates' demise are "greatly exaggerated. It is still heavily used."

Currently, lead chromates are most heavily used in traffic paints—more than half of the lead chromates sold in 1989 were for yellow traffic-marking paints, according to DCMA. National Chemical is exploring lead chromate free replacements for this market, fully aware that some states, Virginia for example, now require lead-free traffic paints and others, such as Minnesota, plan soon to be lead free. In response to demand for lead-free pigments, National Chemical recently introduced a white pigment, strontium phosphate, for use in metal coatings.

David Waldron, vice president and sales manager of Cookson Pigments, Newark, N.J., says people have many misconceptions about lead chromates. Not all lead chromates are created equal. Cookson's silica-encapsulated lead chromates can meet state regulations concerning limits on soluble lead in coatings. "The hazard is soluble lead. It is not a problem if it is not soluble," explains Waldron.

The problem is that people presuppose that all lead is hazardous, Waldron continues. Doctors often require patients to consume quantities of a heavy metal, barium, in the form of barium sulfate in order to take digestive-tract x-rays. This form of barium is not soluble and may be ingested without deadly results, he says. However, if a person ingested a similar quantity of barium chloride, the person would die.

Waldron says that Cookson has engineered its products to have low lead solubility in response to market demand. "We believe the hazard should be controlled, not the ingredient." And he adds that replacement costs for lead chromates are "enormous"—as much as 10 times the cost of lead chromates. "We've discontinued the most soluble of our lead pigments," he says, among them strontium chromates. Cookson also manufactures organic pigments that are not under the same scrutiny as lead-containing pigments. The company recently invested $15 million to build capacity for new organic red pigments—quinacridone, pyroline, and anthraquinone. (Cadmium red pigments, which they replace, are considered to be a health hazard.)

SCM's Borst says his company has perfected a cadmium-selenium pigment that is "low leaching." Cadmium pigments, he admits, have higher temperature and better color retention properties than the cadmium-selenium pigments. However, the cadmium-selenium pigments have been in good demand since their introduction two years ago, he notes.

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Engelhard says that as it loses markets for cadmium pigments, it too is shifting toward replacement pigments. Craig J. Stoneback, specialty minerals and colors marketing director, explains that the company is marketing calcined inorganic pigments such as cobalts, titanates, or zirconates under the Meteor or Meteor Plus tradename. Although these pigments are opaque and durable under exposure to light, they do not have the color brilliance of lead- and chromium-containing pigments, he says. In some instances, the calcined inorganics may be offered in blends with heavy-metal pigments, but, cautions Stoneback, that is not happening now.

Donald P. Miller, trade sales colorants marketing director for Hüls America, says the company has offered heavy-metal replacements for lead chromates for 10 to 15 years, but they are five times more expensive. Users, he notes, are reluctant to "go lead free" unless they are told to do so. He says, "We would like to get rid of them in our plants even though they are a small part of our overall business." One barrier to conversion to lead-free pigments is that state governments are heavy users of those pigments in traffic paints. Miller points out that especially during these fiscally difficult times, governments do not want to spend the extra money for organic yellow traffic paints.

Harcross Pigments, until recently a part of Pfizer, manufactures iron oxide pigments that can partly substitute for lead chromate and other heavy-metal pigments. According to marketing manager John F. O'Neil, an entirely organic yellow for traffic paints will be more expensive, will not perform as well, and will not have the same lightfastness as the lead chromates. Without regulations in place, "most of the world would use lead pigments," he concludes.

According to Peter A. Lewis, coatings industry manager for the Sun Chemical colors group, monoaryl yellow may be as durable a traffic-paint pigment as heavy-metal-containing coatings. He does acknowledge that monoaryl yellow is eight times more expensive than lead chromate, but he says paint producers would need only 6 million lb of monoaryl yellow to replace 40 million lb of lead chromates. Sun, he says, manufactures only organic pigments. "Our customers are coming to us for advice on how to formulate away from lead," he says. Sun Chemical produces pigments such as naphthol red, quinacridone red, phthalocyanine blue, and arylide yellow.

"We are benefiting from the move away from heavy-metal pigments," says Rick Campbell, U.S. pigments general manager of organic pigments producer Hoechst Celanese. He decries the notion that heavy-metal pigments perform better than organics. "In our opinion, organic pigments are more light-fast than lead chromates, depending on customer requirements." Lightfastness is really not an issue, he says. He does admit, though, that organic pigments are sometimes significantly higher in cost and applicators may sometimes have difficulty fully hiding an undercoat if they apply a thin top coat film containing only organic pigments. Hoechst Celanese produces pigments such as naphthol reds, diarylide and hansa yellow, carbazole violet, and special azo pigments.

In an interesting twist, Ciba-Geigy has introduced an organic paint additive that it says can replace zinc, lead, or strontium chromate pigments for metal-corrosion protection in paint primer coatings. Tests of the additives have shown they are not mutagenic, according to Ciba-Geigy material safety data sheets, but may produce skin and eye irritation.

Ciba-Geigy is itself a producer of heavy-metal-containing pigments and metal-replacement chemicals. It offers those replacements in two forms based on (2-benzothiazolylthio)-succinic acid. The first, Irgacor 252, is a free acid form, whereas the second, Irgacor 153, is a liquid hydrophobic amine salt. The Irgacors are priced at parity with the heavy-metal systems they are meant to replace, says Tim Geran, coating additives technical representative. Geran adds that although the pricing of the product is meant to offer paint manufacturers an incentive to replace the heavy metals, government regulation will probably provide the best incentive for substitution. □

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